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In-Hospital Outcomes in Minimally Invasive Mitral Valve Surgery: First Results in a Brazilian Single Center

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Abstract

Introduction: Treatments for cardiovascular diseases have increasingly evolved with the tendency to offer minimally invasive or transcatheter procedures instead of conventional sternotomy surgery. In this context, we highlight minimally invasive mitral valve surgery (MIMVS), which has been shown to be an increasingly solid option with some superior results when compared to the conventional technique: better pain control, shorter hospital stays, shorter recovery time, shorter readmission rate in the first postoperative year, better aesthetic results, and lower overall cost. **Aim:** This study aims to evaluate the stages of MIMVS, by primary mitral valve consultation, in our service and compare these results with data from the literature. **Methods:** All electronic medical records of patients who underwent MIMVS for primary mitral valve injury in the Encore Hospital from January 2020 to February 2023 were analyzed. Tabulation and statistical analysis were performed using the Microsoft Excel® program. Quantitative variables were presented as means, standard deviations. **Results:** 46 patients were enrolled in our study (Age: 59.1 ± 12.4 years old; 60.8% Female, BMI: 26 ± 4.4 Kg/m^2, Low risk STS score: 82.6%). The observed 30-day mortality was 2.1%, plastic rate of 23.9%, blood transfusion rate of 41.3%, length of stay in an intensive care bed (ICB) of 3.3 ± 3.3 days and hospital stay of 6.4 ± 5.1 days. **Conclusions:** We noticed that the MIMVS results carried out in our service agree with data from national and international literature with approximately 1.3 days more hospitalization in ICB.

Keywords

Minimally Invasive Surgical Procedures, Mitral Valve, Outcome Assessment, Health Care

1. Introduction

Increasingly, treatments for cardiovascular diseases have evolved with a tendency to offer minimally invasive or transcatheter procedures instead of conventional surgery by sternotomy. The management of mitral valve diseases has not been different. The use of repair techniques or transcatheter prosthesis implantation in addition to the minimally invasive technique has grown a lot in recent years [1] [2]. Specifically concerning the feasibility of minimally invasive mitral valve surgery (MIMVS), numerous high-volume services have adopted this technique as a standard approach [1]. There is also significant amount of literature available, with lack of evidence evidencing superiority or inferiority of MIMVS compared with the regular sternotomy [1].

Surgery using a minimally invasive technique has proven to be an excellent option for the treatment of atrioventricular valve diseases. Surgeons specifically trained in this approach have achieved excellent results compared to those obtained by the sternotomy technique, but with some advantages over the conventional technique, such as: better pain control, shorter hospital stay, shorter recovery time, less need for transfusion of blood products, smaller perioperative infection rates, less need for imaging and laboratory tests and lower readmission rate in the first postoperative year, better aesthetic result and lower overall cost [1] [3] [4] [5]. It is important to mention that many of these findings are based in observational studies and there is still a lack of randomized controlled trials to confirm these results. The absence of a prospective and randomized study for a better degree of evidence comparing traditional surgery with minimally invasive surgery was questioned. In 2023, at the American College of Cardiology congress, the results of the UK Mini Mitral Trial were presented, which demonstrated non-inferiority of the minimally invasive technique compared to the traditional sternal approach [1]-[6].

The present study aims to evaluate the outcomes of MIMVS, for primary valve lesions, in our service and compare these results with data from national and international literature available so far, and thus contribute to the expansion of the database on this procedure. This study was approved by the Research Ethics Committee of the Hospital de Urgências de Goiás under CAAE number: 55996122.0.0000.0033.

2. Methods

Data from 46 patients in the ENCORE Hospital were collected from electronic medical records (Tasy system©. Philips). from January 2020 to February 2023. We included data referring to all patients who underwent MIMVS due to primary mitral valve lesion during the period proposed for the study. It is important to highlight the fact that medical records of patients submitted to MIMVS due to secondary mitral regurgitation were not included in this research. Due to the retrospective nature of the present study, the ethics committee waived the need for the patient's free and informed consent form. For the outcomes analyzed, we followed the definitions of the Mitral Valve Academic Research Consortium (MVARC) regarding mortality, hospitalization, neurological events, myocardial infarction, vascular access and complications, bleeding complications, arrhythmias and disorders of the conduction system and success of the procedure [7] [8]. We chose to adopt these definitions following a standardization to enable a better correlation of data from this work with data from the international literature. Acute kidney injury (AKI) definitions followed the Kidney Disease: Improving Global Outcomes (KDIGO) standard [9]. All the data were first collected directly from the electronic medical records by a single researcher (DMF). After that, all the obtained data were rechecked by another author of this paper (GG), aiming to verify/minimize any potential error in the information collection from the medical records, performed initially by DMF. The tabulation of data was performed using the Microsoft Excel® software in a descriptive manner. Quantitative variables were presented as means and standard deviations. Qualitative variables were presented in absolute numbers and proportions.

3. Surgical Technique

All patients were operated by the same surgeon. The patient is intubated with a monolumen endotracheal tube. A central venous access (CVA) was performed in the right subclavian vein, percutaneously, by the surgeon himself after anesthetic induction.

The patient's right side was elevated in 30˚. The patient was connected to cardiopulmonary bypass (CPB) by cannulation of the femoral artery and vein, usually on the right side, through an oblique incision of approximately 2 cm in the inguinal region after heparinization. To guide the ideal positioning of CPB cannulas, transesophageal echocardiography (TEE) was used. The femoral venous cannulation was adjusted so that the tip of the cannula could be at 2 - 3 cm in the superior vena cava. Femoral arterial cannulation was adjusted so that the tip of the cannula could be placed in the distal abdominal aorta or iliac artery.

Body temperature was maintained around 34˚C and a vacuum-assisted venous drainage was used during the procedure. After lung deflation, a right lateral minithoracotomy of about 4 - 6 cm was performed, just-infra-lateral to the nipple in men and periareolar in women and, eventually, inframammary to access the thorax through the 4th intercostal space. A tissue retractor (Wound Retractor-Surgesleeve-Medtronic or Alexis©) was used to facilitate exposure as shown in **Figure 1**. It can be done video-assisted, or under direct vision. A surgical instrument suitable for minithoracotomies was used to perform the procedures.

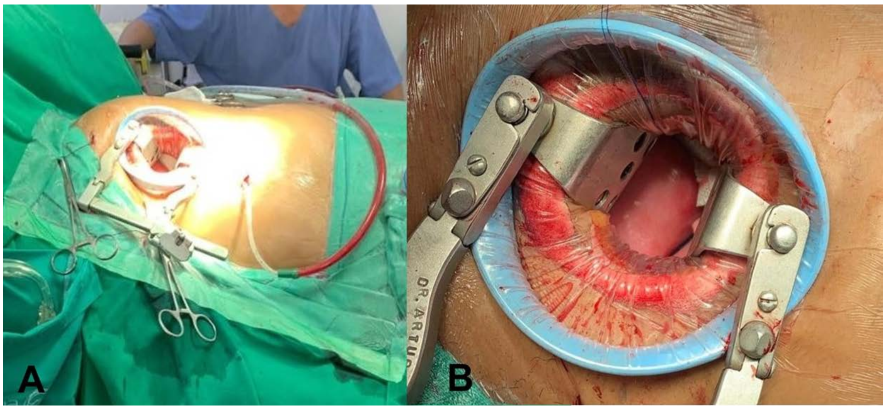

Figure 1. Position of patients and retractors. (A) Patient positioned with a thoracic and a tissue retractor; (B) Better visualization of the thoracic cavity with the thoracic retractor and the tissue retractor.

A small thoracic retractor was used to spread the ribs apart. The pericardium was opened 3 - 4 cm anteriorly and parallel to the phrenic nerve from the ascending aorta distal to the diaphragm. Clamping aorta was performed using a Chitwood clamp inserted through a thoracic access of approximately 10 mm performed in the second intercostal space in the mid-axillary line. When used, a camera, for video-assisted support, was introduced through a 5 mm port in the 4^{th} right intercostal space, below the surgical incision.

About 20 ml/Kg of the cardioplegia solution (Del Nido Solution©) was injected anterogradely into the aortic root, through a long cardioplegia cannula (14 G) over 5 to 8 minutes and repeated after 90 - 120 minutes if necessary.

The mitral valve was accessed through a para-septal incision and a left atrial retractor (specific for minithoracotomies) was used to expose the mitral valve. After repair or replacement, the patient was weaned off CPB to assess the quality of the intervention with transesophageal echocardiography and complete the deaeration process. Then CPB was quickly resumed, the second plan of closure of the left atrium was performed, the cardioplegia cannula was removed and the definitive exit from CPB was performed. Heparin reversal, hemostasis review, right thoracic drainage with Blake drain No. 24 and appropriate closure were performed. The result of the scar is presented in Figure 2.

4. Results

From 46 medical records analyzed, we observed that only one surgery occurred in an emergency setting: severe acute mitral insufficiency due to acute bacterial endocarditis. The selection of patients for the intervention considered the national and international guidelines on valvular heart disease. The minimally invasive modality was adopted for every primary intervention.

4.1. Demographic Characteristics and Type of Valve Lesions

The demographic characteristics of the patients submitted to MIMVS are described in Table 1. In about 30% of the medical records, it was not possible to

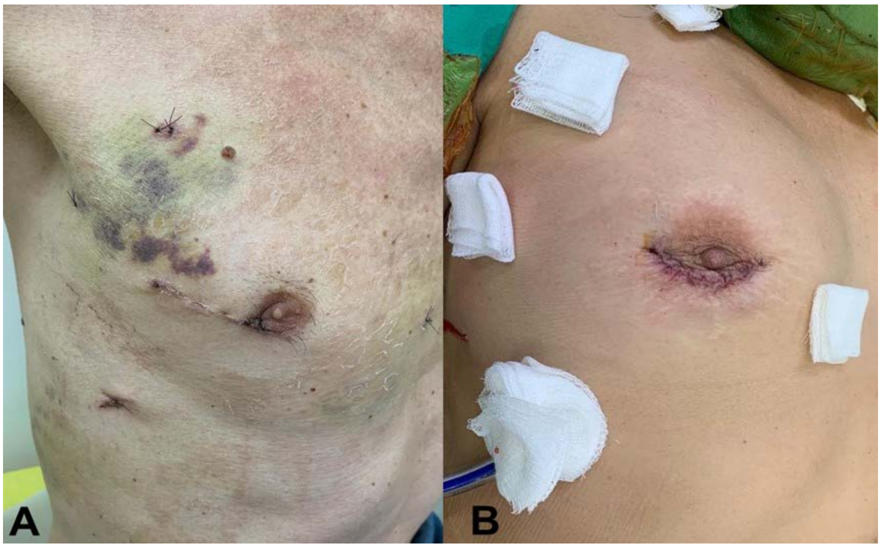

Figure 2. Final results of scars in the immediate postoperative period. (A) Scar from the right lateral minithoracotomy in a male patient; (B) Scar from a perialveolar minithoracotomy in a female patient.

identify the etiology of the mitral lesion (if rheumatic, degenerative, due to prolapse, etc.), therefore, we only classified the type of lesion (insufficiency, stenosis or double lesion) which is shown in **Table 2**.

4.2. Surgery Characteristics

Table 3 shows the characteristics related to the surgery. In describing the length of stay, both in the intensive care unit (ICU) and general hospital length of stay (LOS), we adopted the strategy of presenting these data in subgroups of days because, due to our small sample size, there was one patient who had a prolonged hospital stay which was very different from the average in relation to most patients. However, the average length of stay in an ICU was 3.3 ± 3.3 days, and the average HS was 6.4 ± 5.1 days. When we analyze the last 12 months only, the mean ICU stay was 2.3 ± 1.7 days, and the mean LOS was 4.9 ± 2.4 days.

4.3. Complications

Table 4 and **Table 5** show the major and minor complications respectively. Noting that the definitions of complications follow those described by the MVARC except for the definition of acute kidney injury, in which we use the KDIGO definition, which is more up to date in relation to the Acute Kidney Injury Network (AKIN) definition. Eleven (23.9%) of the 46 patients did not have any surgical complications. As major complications, the 30-day mortality was 2.1% (1 patient). Low cardiac output syndrome during more than 48 hours was observed in 12 patients (26%) and renal injury KDIGO II-III was present in 13% of the sample. Considering minor complications, the most frequent was the necessity of blood transfusion (41.3%), followed by low cardiac output syndrome lasting less than 24 hours (36.9%) and renal injury (KDIGO I) was observed in 17.3%

Table 1. Baseline characteristics.

	n = 46
Age, years (mean ± SD)	59.1 ± 12.4
Female, n (%)	28 (60.8%)
Body Mass Index, Kg/m^2 (mean ± SD)	26 ± 4.4
STS score	
Low risk, n (%)	38 (82.6%)
Intermidiary risk, n (%)	8 (17.3%)
High risk, n (%)	0
Diabetes Mellitus, n (%)	6 (13.4%)
Systemic arterial hypertension, n (%)	25 (54.3%)
Atrial fibrillation, n (%)	13 (28.2%)
Peripheral vascular didease, n (%)	1 (2.1%)
eGFR < 60 ml/min/1.73m^2, n (%)	3 (6.5%)
Stroke, n (%)	5 (10.8%)
Transient ischaemic attack, n (%)	1 (2.1%)
Myocardial infarction, n (%)	1 (2.1%)
Coronary atherosclerotic disease, n (%)	3 (6.5%)
Myocardial revascularization, n (%)	3 (6.5%)
Chronic obstructive pulmonar disease, n (%)	4 (8.6%)
Endocarditis, n (%)	1 (2.1%)
Left Atrium size, mm (mean ± SD)	49.4 ± 7.6
EDDLV, mm (mean ± SD)	53.7 ± 7.6
Left ventricular ejection fraction	
≤40%, n (%)	0
41% - 49%, n (%)	1 (2.1%)
≥50%, n (%)	43 (93.7%)
Not found	2 (4.3%)
Probability for PAH	
Low probability, n (%)	13 (28.2%)
Moderate probability, n (%)	8 (17.4%)
High probability, n (%)	22 (48%)
Not found	3 (6.4%)

EDDLV: End-diastolic diameter of left ventricle. eGFR: estimated glomerular filtration rate. PAH: pulmonary arterial hypertension. SD: Standard deviation. STS: Society of Thoracic Surgeons.

Table 2. Mitral valve disease aetiology.

	n = 46
Regurgitation, n (%)	24 (52.1%)
Stenosis, n (%)	4 (8.7%)
Combined, n (%)	18 (39.2%)

Table 3. Surgery characteristics.

	n = 46
Mitral valve repair, n (%)	11 (23.9%)
Mitral valve replacement, n (%)	35 (76.1%)
CPB time, min (mean ± SD)	113.8 ± 25.4
Aortic closs-clamp time, min (mean ± SD)	76.3 ± 20
Atrial fibrilation concomitant surgery, n (%)	3 (6.5%)
Conversion to sternotomy, n (%)	1 (2.1%)
Arterial cannulation	
Femoral, n (%)	46 (100%)
Axilar, n (%)	0
Canulação venosa	
Femoral, n (%)	46 (100%)
Axillary, n (%)	0
Implanted prosthesis	
Biological, n (%)	33 (94.2%)
Mechanical, n (%)	2 (5.8%)
Intensive care unit stay	
1 day, n (%)	7 (15.2%)
2 days, n (%)	18 (39.1%)
3 days, n (%)	9 (19.5%)
4 to 5 days, n (%)	6 (13.1%)
≥6 days, n (%)	6 (13.1%)
Hospital stay	
≤4 days, n (%)	17 (37%)
5 days, n (%)	10 (21.8%)
6 days, n (%)	5 (10.9%)
7 to 9 days, n (%)	9 (19.5%)
≥10 days, n (%)	5 (10.8%)
Extubation in operating room	38 (82.6%)

CPB: Cardiopulmonary by-pass. SD: Standard deviation.

Table 4. 30-day complications: Major complications.

30-day mortality, n (%)	1 (2.1%)
Convertion to stenotomy, n (%)	1 (2.1%)
Myocadial infarction, n (%)	0
Stroke, n (%)	0
Renal injury, KDIGO II-III, n (%)	6 (13%)
Re-intervention, n (%)	0
Prolonged ventilation > 48 hours, n (%)	2 (4.2%)
LCOS > 48 horas, n (%)	12 (26%)
LCOS with mechanical support, n (%)	0

KDIGO: Kidney Disease Improving Global Outcomes. LCOS: Low cardiac output syndrome.

Table 5. 30-day complications: Minor complications.

Transient ischaemic attack, n (%)	0
New onset of atrial fibrilation, n (%)	6 (13%)
New pacemaker, n (%)	0
Pericardial effusion*, n (%)	0
Pleural effusion*, n (%)	3 (6.5%)
Pneumothorax*, n (%)	1 (2.1%)
Pneumonia, n (%)	4 (8.6%)
Urinary tract infection, n (%)	1 (2.1%)
Groin infection, n (%)	0
Renal injury KDIGO I, n (%)	8 (17.3%)
Phrenic nerve palsy, n (%)	0
Blood transfusion, n (%)	19 (41.3%)
LCOS < 24 hours, n (%)	17 (36.9%)

*Requiring drainage. KDIGO: Kidney Disease Improving Global Outcomes. LCOS: Low cardiac output syndrome.

of patients.

5. Discussion

Mitral valve repair (MVR) has been established as the gold standard treatment for severe mitral insufficiency since the publication of the initial repair techniques by Alain Carpentier [10] [11] and in cases where repair is not possible, mitral valve replacement (MVRP) becomes an option. With the increasing use of laparoscopy and thoracoscopy surgery, the minimally invasive approach to cardiac surgery also happened. Specialized centers began to publish minimally invasive approaches to the mitral valve in mid-1990 [12]. These procedures started with a partial sternotomy approach or parasternal access, but the parasternal access was abandoned [13] [14] [15] [16] [17]. Following the evolution of technology, the technique continued to evolve from the video-assisted approach to robotic surgery, which is already performed in some centers [12].

There was a lot of questioning, at first, whether the minimally invasive approach would be better or, at least, equivalent to the traditional median sternotomy. In the initial studies, the longer CPB time, surgeon's lesser visibility and, in some studies, the increased need for blood transfusions was the triggers for this questioning. However, with the evolution of the technique, surgical materials and gain in experience of services and surgeons, nowadays, there is significant evidence of some benefits of minimally invasive technique in relation to median sternotomy; benefits such as: improved survival, better pain control, shorter hospital stay, shorter recovery time, less need for transfusion of blood products, lower rates of perioperative infection, less need for imaging and laboratory tests and lower readmission rate in the first postoperative year, better aesthetic result and lower overall cost, lower risk of thromboembolism, endocarditis and hemorrhage related to anticoagulation [1] [3] [4] [5] [11] [12] [18]-[26].

One difficulty we encountered in comparing our data was the lack of standardization in the definitions of complications and in the way of presenting them. To enable future comparisons with our data, we chose to use the MVARC criteria as described in the methods topic. It is noteworthy that our rate of mitral valve repair was 23.9%, which differs from the international literature, but corroborates with the Brazilian data shown by Costa *et al.* [23] that the rate of mitral valve repair in Brazil is still low due to the limitation of adequate training, as well as the non-coverage of materials for repair surgery by some health plans and even by the Health Unic System from Brazil. This can be a confounding factor, as complications and 30-day mortality are generally lower in valve repair patients when compared to valve replacement patients [1].

Analyzing the 30-day mortality, we found a rate of 2.1%, which corresponds to a patient who died due to arrhythmia (sudden death due to asystole) eleven days after valve replacement surgery, in the context of an emergency, due to severe mitral regurgitation resulting from acute bacterial endocarditis (ABE). In the context of ABE, Shih *et al.* [27] found a mean in-hospital mortality of 9.4% (7% - 23%) in their systematic review published in 2021. In the general context of MIMVS, the 30-day mortality found by Davierwala *et al.* [11], in their publication "The Leipzig experience", was 0.8%. Sündermann *et al.* 2015 [20] published a review that indicated a mortality rate of 1.4%. Paparella *et al.* [4] found a mortality rate of 1.2% in their review of Italian centers. Ko *et al.* [1] found a mortality rate of 0.4% when performing valve repair and 2.9% when replacing the valve but cites groups that reached up to 4.2%. Gammie *et al.* [26] found a mortality rate of 1.75%.

Our blood transfusion rate was 41.3%. In the rest of the comparative literature [4] [11] [20] [26], the mean ranged from 25.9% to 41%. Ko *et al.* [1] found a rate of 43.7% for valve replacement and 24.9% for valve repair. It is worth mentioning here that, if we analyze only the last twelve months, our transfusion rate was 34.7%, which denotes an improvement in the service's learning curve.

The average ICU stay was 4.2 (±5) days and the HS time was 7.2 (±6) days. We chose to present these variables in the form of groups of days per patient, in **Table 3**, due to the aforementioned reason. In the comparative literature [1] [4] [11] [19] [20] [26], the average ICU stay was 1.8 (±1) day, and the average hospital stay was 5 to 12.2 (±9.4) days. When we analyze only the last 12 months, the average ICU stay was 2.3 ± 1.7 days, and the average HS was 4.9 ± 2.4 days, much closer to centers of excellence in the world.

We had no case of acute myocardial infarction or stroke. Our CPB and aortic clamping times are very similar to the comparative literature [1] [4] [11] [19] [20] [26]. We had only one case that required conversion to sternotomy due to intraoperative bleeding that was difficult to identify through the thoracotomy window.

It was not possible to compare the duration of mechanical ventilation, as 82.8% of our patients were extubated while still in the operating room, which is the result of a great effort by the cardiovascular surgery, anesthesiology, and intensive care team to provide greater safety and better recovery for the patients. When only the last 12 months are analyzed, the in-room extubation rate was 95.6%.

There are some limitations in our study that should be mentioned. The study is retrospective with all inherent limitations. The number of patients is small. And the variables are subject to several time-related biases such as the team's experience.

In general, we can observe that, except for the repair surgery rate, our data are consistent with the international literature, thus reinforcing the viability and safety of MIMVS.

6. Conclusion

MIMVS has already been a technique used all over the world, with great safety results at short and medium-term follow-up. We can observe that our results are similar to those in the national and international literature with the length of stay in the ICU 1.3 day longer.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Ko, K., De Kroon, T.L., Post, M.C., Kelder, J.C., Schut, K.F., Saouti, N. and Van Putte, B.P. (2020) Minimally Invasive Mitral Valve Surgery: A Systematic Safety Analysis. *Open Heart*, **7**, e001393. https://doi.org/10.1136/openhrt-2020-001393

[2] Abu-Omar, Y., Fazmin, I.T., Ali, J.M. and Pelletier, M.P. (2021) Minimally Invasive Mitral Valve Surgery. *Journal of Thoracic Disease*, **13**, 1960-1970. https://doi.org/10.21037/jtd-20-2114

[3] Vervoort, D., Nguyen, D.H. and Nguyen, T.C. (2020) When Culture Dictates Prac-

tice: Adoption of Minimally Invasive Mitral Valve Surgery. *Innovations* (*Phila*), **15**, 406-409. https://doi.org/10.1177/1556984520948644

[4] Paparella, D., Fattouch, K., Moscarelli, M., Santarpino, G., Nasso, G., Guida, P., Margari, V., Martinelli, L., Coppola, R., Albertini, A., Del Giglio, M., Gregorini, R. and Speziale, G. (2020) Current Trends in Mitral Valve Surgery: A Multicenter National Comparison between Full-Sternotomy and Minimally-Invasive Approach. *International Journal of Cardiology*, **306**, 147-151. https://doi.org/10.1016/j.ijcard.2019.11.137

[5] Nakayama, T., Nakamura, Y., Kanamori, K., Hirano, T., Kuroda, M., Nishijima, S., Ito, Y., Tsuruta, R. and Hori, T. (2020) Early and Midterm Results of Minimally Invasive Aortic and Mitral Valve Surgery via Right Mini-Thoracotomy. *Journal of Cardiothoracic Surgery*, **35**, 35-39. https://doi.org/10.1111/jocs.14313

[6] Santana, O., Larrauri-Reyes, M., Zamora, C. and Mihos, C.G. (2016) Is a Minimally Invasive Approach for Mitral Valve Surgery More Cost-Effective than Median Sternotomy? *Interdisciplinary CardioVascular and Thoracic Surgery*, **22**, 97-100. https://doi.org/10.1093/icvts/ivv269

[7] Goldfarb, M., Drudi, L., Almohammadi, M., Langlois, Y., Noiseux, N., Perrault, L., Piazza, N. and Afilalo, J. (2015) Outcome Reporting in Cardiac Surgery Trials: Systematic Review and Critical Appraisal. *Journal of the American Heart Association*, **4**, e002204. https://doi.org/10.1161/JAHA.115.002204

[8] Stone, G.W., Adams, D.H., Abraham, W.T., Kappetein, A.P., Généreux, P., Vranckx, P., Mehran, R., Kuck, K.H., Leon, M.B., Piazza, N., Head, S.J., Filippatos, G. and Vahanian, A.S. (2015) Clinical Trial Design Principles and Endpoint Definitions for Transcatheter Mitral Valve Repair and Replacement: Part 2: Endpoint Definitions: A Consensus Document from the Mitral Valve Academic Research Consortium. *European Heart Journal*, **36**, 1878-1891. https://doi.org/10.1093/eurheartj/ehv333

[9] Kidney Disease: Improving Global Outcomes (KDIGO) Acute Kidney Injury Work Group (2012) KDIGO Clinical Practice Guideline for Acute Kidney Injury. *Kidney International*, **2**, 1-138.

[10] Carpentier, A. (1983) Cardiac Valve Surgery—The "French Correction". *The Journal of Thoracic and Cardiovascular Surgery*, **86**, 323-337. https://doi.org/10.1016/S0022-5223(19)39144-5

[11] Davierwala, P.M., Seeburger, J., Pfannmueller, B., Garbade, J., Misfeld, M., Borger, M.A. and Mohr, F.W. (2013) Minimally Invasive Mitral Valve Surgery: "The Leipzig Experience". *Annals of Cardiothoracic Surgery*, **2**, 744-750.

[12] Burns, D.J.P., Wierup, P. and Gillinov, M. (2021) Minimally Invasive Mitral Surgery: Patient Selection and Technique. *Cardiology Clinics*, **39**, 211-220. https://doi.org/10.1016/j.ccl.2021.01.003

[13] Detter, C., Boehm, D.H. and Reichenspurner, H. (2004) Minimally Invasive Valve Surgery: Different Techniques and Approaches. *Expert Review of Cardiovascular Therapy*, **2**, 239-251. https://doi.org/10.1586/14779072.2.2.239

[14] Arom, K.V. and Emery, R.W. (1997) Minimally Invasive Mitral Operations. *The Annals of Thoracic Surgery*, **63**, 1219-1220. https://doi.org/10.1016/S0003-4975(97)00136-7

[15] Svensson, L.G. and D'Agostino, R.S. (1998) "J" Incision Minimal-Access Valve Operations. *The Annals of Thoracic Surgery*, **66**, 1110-1112. https://doi.org/10.1016/S0003-4975(98)00655-9

[16] Navia, J.L. and Cosgrove, D.M. (1996) Minimally Invasive Mitral Valve Operations. *The Annals of Thoracic Surgery*, **62**, 1542-1544.

https://doi.org/10.1016/0003-4975(96)00779-5

[17] Doty, D.B., DiRusso, G.B. and Doty, J.R. (1998) Full-Spectrum Cardiac Surgery through a Minimal Incision: Mini-Sternotomy (Lower Half) Technique. *The Annals of Thoracic Surgery*, **65**, 573-577. https://doi.org/10.1016/S0003-4975(97)01368-4

[18] Van Praet, K.M., Stamm, C., Sündermann, S.H., Meyer, A., Unbehaun, A., Montagner, M., Nazari Shafti, T.Z., Jacobs, S., Falk, V. and Kempfert, J. (2018) Minimally Invasive Surgical Mitral Valve Repair: State of the Art Review. *Interventional Cardiology Journal*, **13**, 14-19. https://doi.org/10.15420/icr.2018.13.2.ER1

[19] Castro Neto, J.V., Melo, E., Fernandes, J., Gomes, R., Freitas, C., Machado, J., Martins, F., Barbosa, A., Oliveira, B. and Gondim, C. (2012) Mitral Valve and Atrial Septal Defect Surgery: Minimally Invasive or Sternotomy Approach. *Arquivos Brasileiros de Cardiologia*, **99**, 681-687. https://doi.org/10.1590/S0066-782X2012005000064

[20] Sündermann, S.H., Czerny, M. and Falk, V. (2015) Open vs. Minimally Invasive Mitral Valve Surgery: Surgical Technique, Indications and Results. *Cardiovascular Engineering and Technology*, **6**, 160-166. https://doi.org/10.1007/s13239-015-0210-5

[21] David, T.E., David, C.M., Tsang, W., Lafreniere-Roula, M. and Manlhiot, C. (2019) Long-Term Results of Mitral Valve Repair for Regurgitation Due to Leaflet Prolapse. *Journal of the American College of Cardiology*, **74**, 1044-1053. https://doi.org/10.1016/j.jacc.2019.06.052

[22] Suri, R.M., Schaff, H.V., Dearani, J.A., Sundt, T.M., Daly, R.C., Mullany, C.J., Enriquez-Sarano, M. and Orszulak, T.A. (2006) Survival Advantage and Improved Durability of Mitral Repair for Leaflet Prolapse Subsets in the Current Era. *The Annals of Thoracic Surgery*, **82**, 819-826. https://doi.org/10.1016/j.athoracsur.2006.03.091

[23] Costa, F.D.A.D., Colatusso, D.F.F., Martin, G.L.D.S., Parra, K.C.S., Botta, M.C., Balbi Filho, E.M., Veloso, M., Miotto, G., Ferreira, A.D.A. and Colatusso, C. (2018) Long-Term Results of Mitral Valve Repair. *Brazilian Journal of Cardiovascular Surgery*, **33**, 23-31.

[24] Sündermann, S.H., Sromicki, J., Rodriguez Cetina Biefer, H., Seifert, B., Holubec, T., Falk, V. and Jacobs, S. (2014) Mitral Valve Surgery: Right Lateral Minithoracotomy or Sternotomy? A Systematic Review and Meta-Analysis. *The Journal of Thoracic and Cardiovascular Surgery*, **148**, 1989-1995.e4. https://doi.org/10.1016/j.jtcvs.2014.01.046

[25] Al Otaibi, A., Gupta, S., Belley-Cote, E.P., Alsagheir, A., Spence, J., Parry, D. and Whitlock, R.P. (2017) Mini-Thoracotomy vs. Conventional Sternotomy Mitral Valve Surgery: A Systematic Review and Meta-Analysis. *The Journal of Cardiovascular Surgery* (*Torino*), **58**, 489-496. https://doi.org/10.23736/S0021-9509.16.09603-8

[26] Gammie, J.S., Zhao, Y., Peterson, E.D., O'Brien, S.M., Rankin, J.S. and Griffith, B.P. (2010) J. Maxwell Chamberlain Memorial Paper for Adult Cardiac Surgery. Less-Invasive Mitral Valve Operations: Trends and Outcomes from the Society of Thoracic Surgeons Adult Cardiac Surgery Database. *The Annals of Thoracic Surgery*, **90**, 1401-1408, 1410.e1. https://doi.org/10.1016/j.athoracsur.2010.05.055

[27] Shih, E., Squiers, J.J. and DiMaio, J.M. (2021) Systematic Review of Minimally Invasive Surgery for Mitral Valve Infective Endocarditis. *Innovations* (*Phila*), **16**, 244-248. https://doi.org/10.1177/1556984521997086